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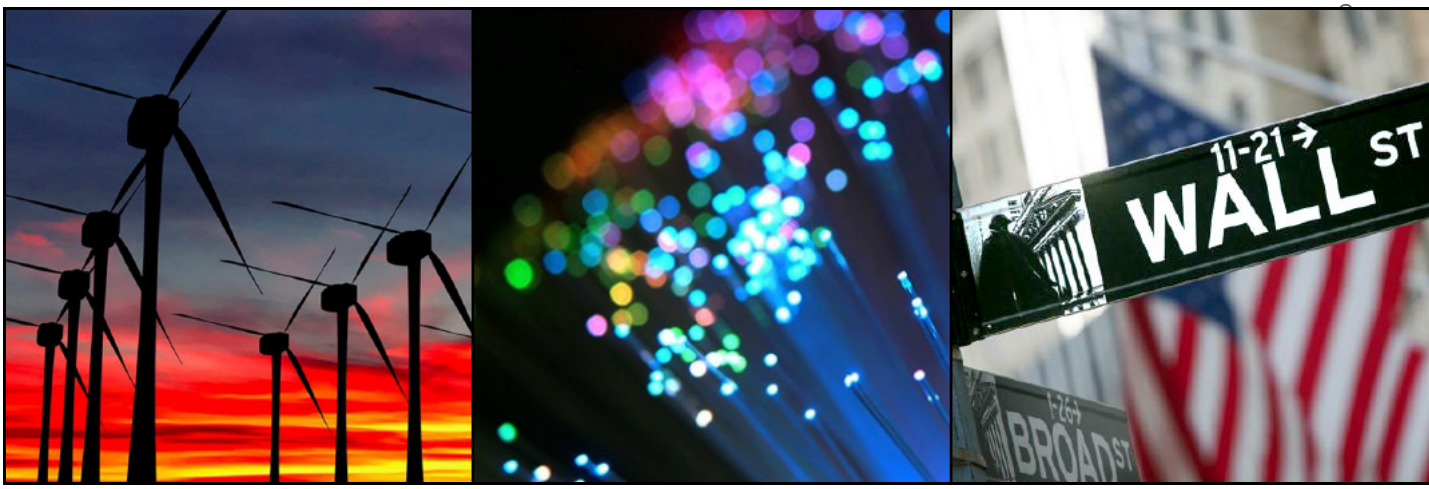
Synchronization Markets

1. About Timing and Synchronization

Relevant sectors of the industry --including Telecom, Finance, Energy, Broadcast, IoT, and Traffic Control-- require accurate and reliable synchronization. Timing is so essential that small perturbations may break a phone call, induce a power blackout, lead to chaos in airports or cause millionaire losses in the stock market. In principal GNSS (Galileo, GPS) could satisfy timing needs, however stand-alone GNSS solutions are not reliable because noise is always present and failures may occur, while cyberattacks, jamming and spoofing are real threats. Moreover, the use of individual GNSS receivers is not practical at all because servers, routers or switches do not use to have dedicated timing interfaces.

State-of-the-art solutions are based on synchronization nodes --equipped with a good oscillator and a GNSS receiver-- that distribute timing by means of time-stamped packets. This is the basic concept of NTP (Network Time Protocol) that was developed in the 80's to synchronize computer systems attached to private or public networks. However, despite its popularity and massive deployment it is not good enough for today' requirements. The alternative is PTP (Precision Time Protocol) which improves the accuracy and robustness.

Figure 1 *xGenius a tester to verify Synchronization networks.*



2. EXCELLENCE IN TIMING

2.1 Challenges and solutions

The Global Market

GNSS market for synchronization is witnessing a consistent growth bolstered by macroeconomic stability, market maturity and continuous diversification of telecommunication services. Despite gradual saturation in North America and Western Europe, the global installed base will increase from 1.8 Millions of devices in 2017 to almost 2.5 in 2020 according to the GNSS agency. The growth is due to the increased number of applications in many areas and for sure the demand will also grow particularly depending on the evolution of IoT technologies that will also require timing services.

Synchronization is indeed at the core of many vital infrastructures, nevertheless, the concept of precise timing varies depending on the application:

1. **Optical and Mobile operators** require accurate synchronization being essential to deliver the service.
   - *Public Switched Telephone Network*: to provide time slot framing and time distribution.
   - *Satellites*: frequency is required in Control Stations and Gateways.
   - *Wireless LTE*: need accurate timing at base stations for hand-overs, location and billing.
   - *5G small cells deployment*: must have frequency and phase alignment for spectrum management.
2. **Power Utilities** need an accurate time source to monitor the energy flow, tele-protection control, log events chronologically and to report analytic. In order to achieve it, smart grids are deploying PMU (Phasor Measurement Units) across substations to supply a precise timing at nodal points.
3. **Finance institutions** are legally committed to trace operations with a consistent and accurate time scale.

- *Banks*: timing is used to log transactions chronologically and be able to recreate causal links.
- *Stock Exchanges*: all the operations in the continuous market must be time-stamped for security and tracing.
- According to the European Securities and Markets Authority (ESMA) accurate timing and traceability is imperative to confirm when transactions occur (Directive MiFID 2, since 01/01/18).

4. **Internet of Things** is pushing to unprecedented bandwidth, connectivity and mobility requirements. New applications, such as autonomous driving and drones, require synchronization for control and location.

2.2 It is the economy stupid

At least the 10% of developed countries economy depend today on GNSS, which entails millionaire investments. It is obvious that the control of the time is major priority for the most advanced regions then GPS at the US, GLONASS in Russia, BEIDO in China, and GALILEO in Europe is the most notorious evidence. Synchronization is a real need in many aspects of the daily live for instance to use trains and airplanes, to make a phone call, to get cash from an ATM, to use Electricity, to connect the Internet, or even to watch TV.

The lack of good timing may cause not only failures, but also collateral effects... and this is not new at all. For instance do you know that the virtuoso writers Shakespeare and Cervantes died the same day? Well, at least officially both died on April 23 in 1616, but the truth is that they passed away with 10 days of difference because England was still using the never synchronized Julian calendar but Spain had already adopted the Gregorian calendar.

This could be anecdotal but poor synchronization may cause major disasters.

GPS timing failure

A GPS failure occurred on 01/26/16, when US Air Force decommissioned one satellite and GPS begun to broadcast wrong time information. Impact was different --depending on the typologies, back-ups and earth location-- but thousands of alarms were generated in the world during the event and some users entered in panic. For instance, the BBC digital audio transmitters interfered each other. The GPS failure also caused serious problems in a particular aircraft when the Embraer E190's, experienced clock errors showing weird charts and fast running time. Similar failures occurred to GPS on 01/01/04, GLONASS on 04/01/14, and GALILEO on 01/19/17.

Blackout

The largest blackout in the American power grid since 1950 occurred on 08/14/03 affecting 50 million people and more than 70,000 MWatts of electrical load. Although power was restored within hours, some areas did not for two weeks. To discover the causes NERC investigators labored over thousands of data items to get the exact time sequence of events, it was like putting together small pieces of a very large puzzle. A valuable lesson was the importance of having a time traceable system based on GPS.

It is obvious that many of critical infrastructures depend on GNSS synchronization, then, it is necessary to increase the level of protection and reliability because there are many new threats. For instance, at DEFCON (world's largest hacker convention) was presented a low-cost GNSS spoofer that demonstrated how simple is to disturb GPS or GALILEO signals.

But we can find many more evidences: North Korea has been jamming GPS in South Korea threatening the safety of civilian aircraft, vessels and violating international treats as Seoul reported to the UN Security Council (Reuters). Last sample: Russia jammed European phones and GPS signal during military drills (Washington Post).

The conclusion is that stand-alone GNSS installations are highly vulnerable.

Figure 2 *Clock synchronizing a network by means of PTP.*

2.3 What exactly the problem is?

Industry and Regulators know the dramatic consequences that a bad synchronization may cause, but procedures to verify and keep timing under control is costly and usually only activated when the degradation is affecting the service. Why they are not more proactive? Because of two reasons:

1. Synchronization testing and monitoring is complex and only high profile engineers can do it.
2. The deployment of automatic probes with monitoring features in critical point is expensive and bulky.

We can see it using another perspective:

(a) from a business point of view, GNSS systems are required to reduce the Cost of installation and maintenance;

(b) from a technical point of view, key requirements of GNSS are Accuracy, Authentication and Robustness in order to minimize failures and maximize Availability.

Therefore, we may conclude that there is a market niche for a Synchronization node with automatic Test and Monitoring functions because standalone GNSS has weakness.

Table 1

Synchronization Requirements per industry.

	Telecom	*Power*	*Finance*	*Transport*	*Broadcast*
Accuracy	sub-microsecond	Microsecond	100 microsecond	Microsecond	10 microsecond
Requirements	Frequency Phase	Frequency Phase ToD	Frequency Phase ToD	Frequency	Frequency Phase
Features	Authentication Robustness Availability	Authentication Redundancy Availability	Authentication Traceability	Robustness Availability	Availability

2.4 Market's state-of-the-art

At the end of the day accuracy, availability, traceability, robustness are critical features (see Table 1) that Network Clocks shall always consider before synchronizing the SC always located at 5G Base stations, Power Phasors, Airports and Financial servers.

Why now?

Timing has always been essential, even before of the digital era. Looking backwards, we find how ancient civilizations measured the time by the motion of the sun and moon using obelisks to provide season's time thanks to the shadow because synchronization was already necessary for the agriculture, religious celebrations and any mass event.

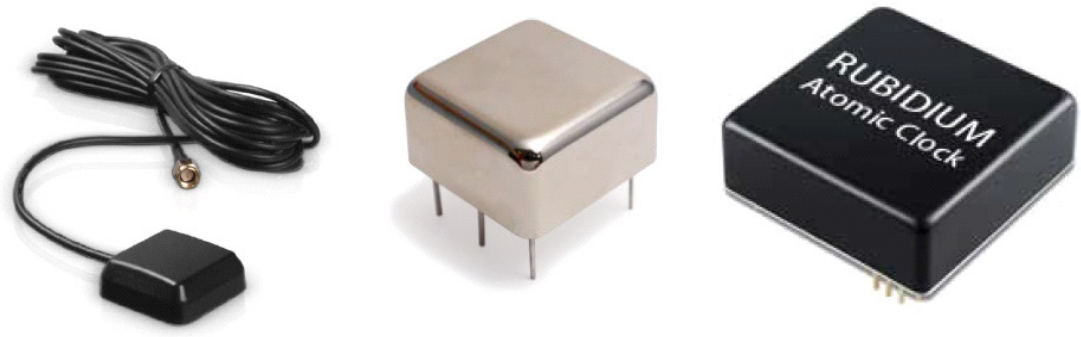


Figure 3 *A GNSSS receive, an OCXO and an Atomic Rubidium oscillator*

Sea navigation was possible without the sand clocks --in combination with the compass-- to position the Galleons on Earth and this technique is still being taught in navigation schools. Mechanical clocks became popular when, at

the beginning of industrial revolution, workers had to arrive on time to the factories, which means that everyone had to be synchronous to be part of the production line.

Be aware that there is something that has always happened. The more developed was the technology the higher time accuracy was required the after the mechanical clocks arrived the quartz clocks that were ready since 1920, Atomic clocks in 1960, while the GNSS era begun in 1980 when constellation of satellites were available..

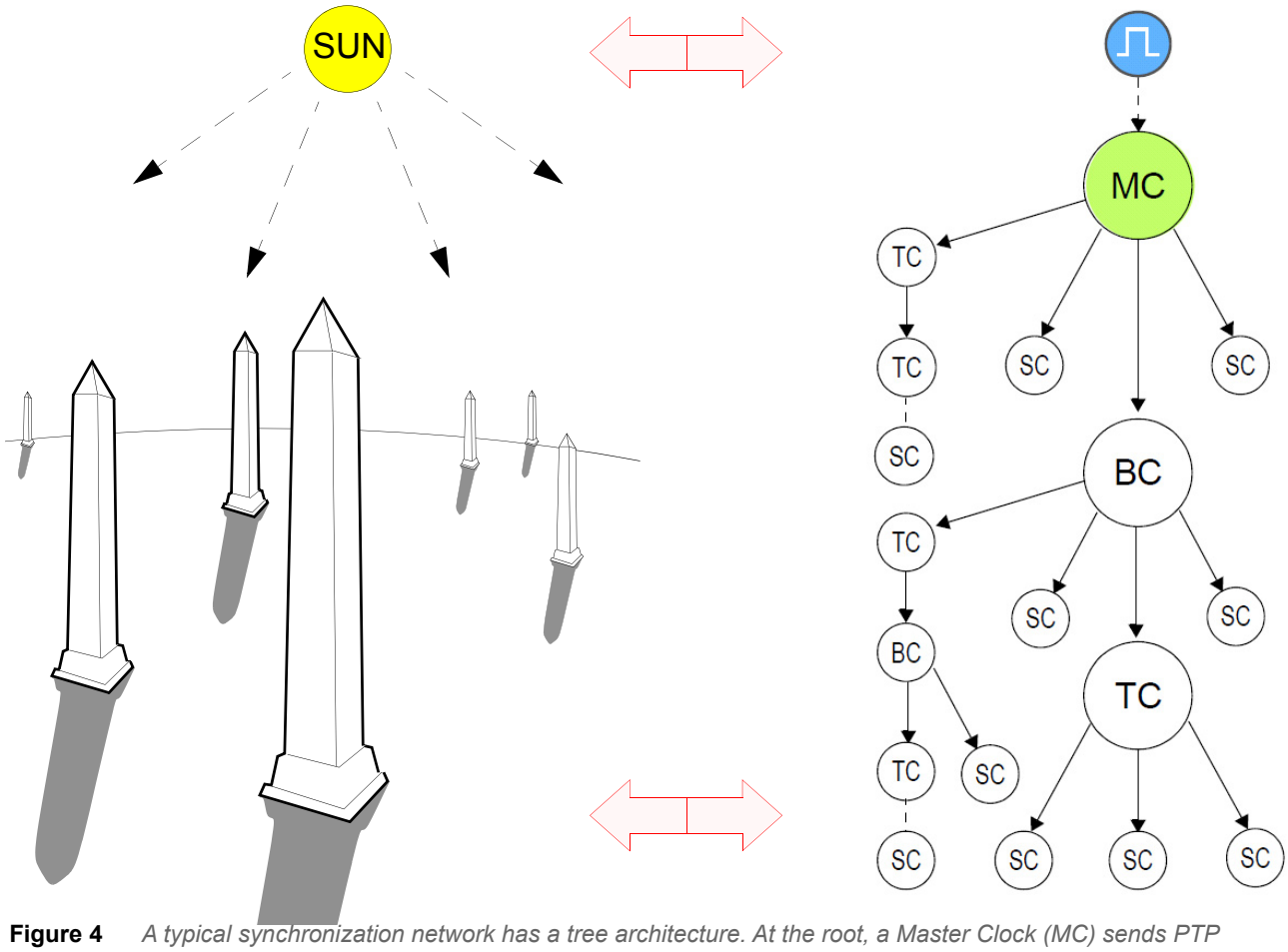


Figure 4 *A typical synchronization network has a tree architecture. At the root, a Master Clock (MC) sends PTP packets to the Slave clocks (SC) to discipline their oscillators. In the branches Boundary (BC) and Transparent Clocks (TC) regenerate and forward the signals. The result is a hierarchical topology with one MC and a number of BC, TC and SC.*

Essentially any synchronization system has a Master clock that provides timing to a number of Slave clocks (see Figure 5), this model repeats everywhere including old Obelisks that are the slave clock while the Sun is the master.

The digital era begun during the 1980 decade when optical transmission networks were unified under a universal standard known as SONET that stands for Synchronous Optical Network. Afterwards, in the 1990 decade when the Internet became popular NTP was adopted as the timing protocol, was ad-

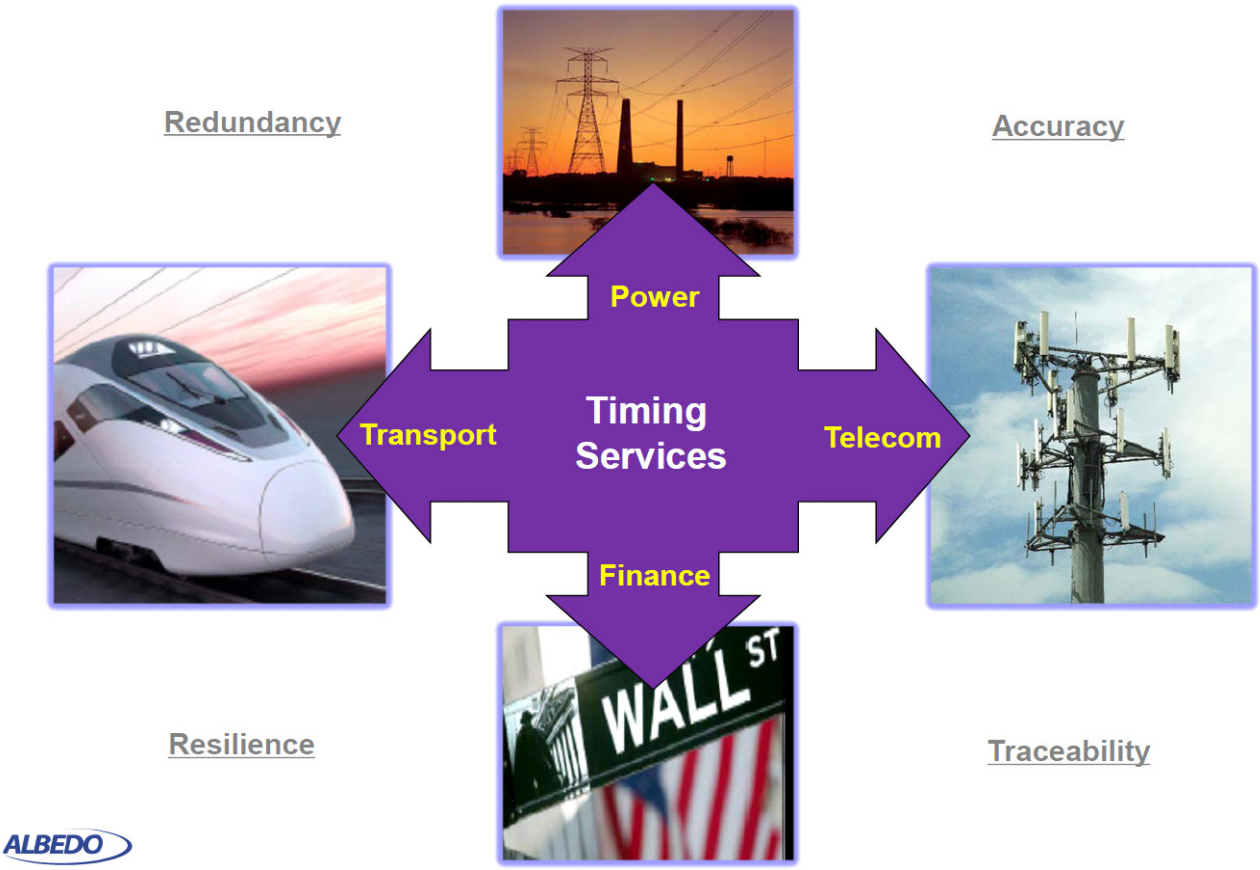


Figure 5 *Market segmentation.*

opted for a lot of applications, nevertheless the lack of accuracy of NTP was an inconvenient and was not used by the most demanding. This was the reason why in 2008 the IEEE develop PTP (Precision Time Protocol), also known as IEEE 1588, to satisfy the higher demands of timing of the industry.

3. Timing Big Players

3.1 Synchronization in the industry

There is an interesting number of industry that require timing to run their critical infrastructures (see Figure 5).

- **Telecom**: Fiber optic, 4G and 5G operators require accurate phase and time alignment at the core of the most critical infrastructures from the central office to the base stations in order to increase the density of terminals, reduce the size, reuse frequencies, billing, event logs, hand-over and many more functions that are improving the whole business. Telecom makes up the majority of timing customers indeed.
- **Power Utilities**: The automation of the power grid requires a synchronism for peak-hour billing, generation of virtual energy and the control of automatic protection failures. When a substation detects an event it is time-stamped and transmitted for traceability and control. Phasors as a

source for timing are migrating to PTP while clocks are deployed across the power grids, which is required due to its distributed nature and the need to balance generation & demand correlation

- **Transport and Industry**: Railways have their own power grid with similar timing requirements to Power utilities with some sophisticated cases when a train breaks produces power back to the grid. Accurate synchronization is essential to ensure optimal operation of converter stations. Road transport services require continuous location of the float while autonomous driving all require precise timing. Interestingly IoT is defining objects embedded with sensors with PTP timing.
- **Aerospace**: Time is a key resource in Navigation Systems to ensure the proper functioning. Inherited signals such as IRIG-B, NTP and TDM are still in use, but progressively are being replaced by PTP time-stamping systems to provide a unique, accurate and consistent signal synchronization based on atomic clocks disciplined by GNSS and distributed through IP networks throughout the territory.
- **Finance**, Banks, Stock exchanges are legally committed to trace operations with a consistent and accurate time, moreover, regulators mandate for highly precision and traceable timing to confirm when any Financial operation occur, including credit card payment, and stock market trade operations to log events in a chronological manner.
- **Broadcasting**: Organizations providing TV and Radio channels need to integrate digital equipment with accurate synchronization in order to manage their studio operations and broadcast transmissions.
- **Other applications**: Including R&D centers and Government.

As part of the activities planned during the project, customer development actions will be undertaken to continue engaging the mentioned companies as potential buyers/users.

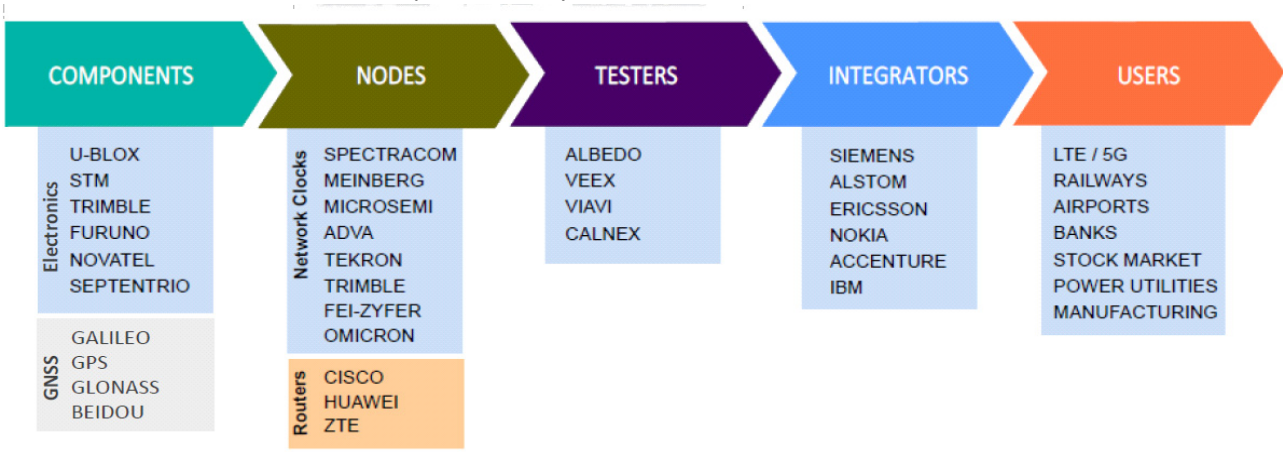


Figure 6 *Market Positioning at the five segments of the market and key players.*

3.2 Segmentation

Timing is segmented into five segments (see Figure 5) each one define a type of company:

1. Components, we find manufacturers of modules, chips, receivers, oscillators, antennas.

2. Nodes, served by manufacturers of synchronization nodes.
3. Testers, companies that bring into the market testers and monitoring appliances.
4. Integrators, this segment belongs to companies that design and install time architectures.
5. Users, which are the final customers running applications requiring synchronization services.

Paying a bit more attention, we find a number of international companies and, interestingly, some of them are already customers while others are competitors:

- Nodes: served by large multinationals such as Microchip / Microsemi / Symmetricom (US), ADVA / Oscilloquartz (Swiss/Israel), Oralia/Spectracom (US), Meinberg (Germany). Most of them are customers!!
- Testers: served by specialized companies such as Anritsu (Japan), Viavi (US), Veex (US), Opwill (China), Calnex (UK) and of course ALBEDO (Spain).

3.3 Nodes Segment

Note that monitoring features belong to the segment identified as Testers. Therefore is not a secret that this will be the main differentiator and the key selling argument. Following specialized sources, we found a size of more than 1.5 million of Synchronization Nodes, which was the world market in 2017, according to the GNSS Agency. The addressable market could be about 800,000 units (see Figure 8).

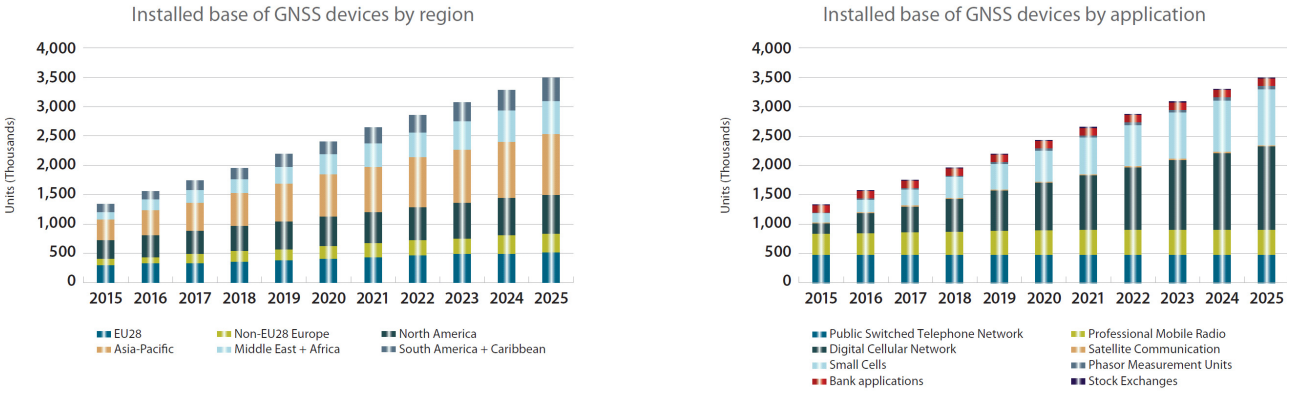


Figure 8 *World GNSS market (source ISBN 978-92-9206-032-9 report at pag. 89)*

Dynamics & Drivers in Telecom market

Despite still is more than the 50% of the market (see Figure 7), several negative factors have occurred in the telecom business in last decades including falling profits as result of competition that squeezes margins, rising expenses

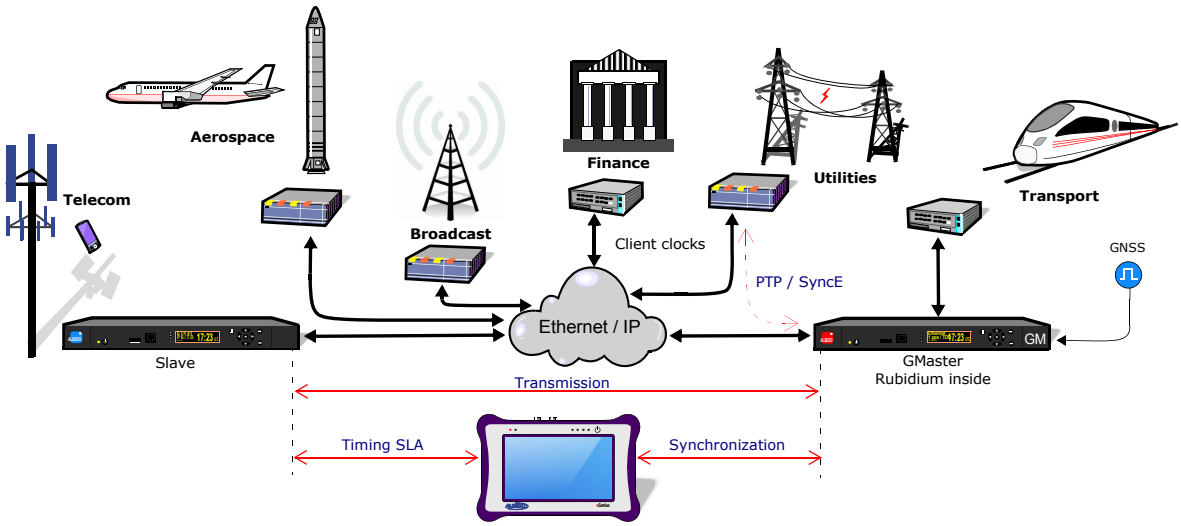


Figure 7 *Markets and Applications.*

because they must continuously expand their networks. Main problem is the heavy debt loads (one of the highest debt-to-equity ratio of any industry) that are pushing to save in Expenditures.

It means that new opportunities for products capable to integrate several functionalities that can reduce CAPEX and OPEX as well because reduce the need to move experts to remote locations.

Future markets

ALBEDO will continue developing new features as we do with all the products without exceptions. For instance increasing the bit rates, adding legacy protocols such as NTP and IEEE 1588v2.1 to facility migration or developing new synchronization profiles for other markets such as IoT, Manufacturing or automatic driving that require highly accurate synchronization and location.

4. About ALBEDO TELECOM inc.

ALBEDO Telecom (www.albedotelecom.com) is a manufacturer of Synchronization nodes, Telecom testers, WAN emulators, Ethernet taps and OTDRs, which core expertise range from PTP, SyncE, GbE, 10GbE, T1/E1, Jitter/Wander, C37.94 and Optical technologies. Most of the customers are Power utilities, Telecom operators, Train/Air traffic control, Military and Universities that use ALBEDO solutions in more than 85 countries. ALBEDO has more 600 of customers in the five continent. For instance: ABB, Bahrat, BSNL, Ceragon, CISCO, China Telecom, Eutelsat, Hydro-Quebec, Idaho Power, Huawei, Indra, Claro, Bosch, Man, NATO, Orange, Pacific Hydro, Tata, Telmex, Siemens, Vodafone, Wind and many more.

ALBEDO has deep understanding in telecoms, quality monitoring systems, test and measurement, engineering and production processes and most importantly the end users -their behavior and needs- we attempt to enrich user experience at all levels. We develop projects from scratch and with special emphasis on ergonomics. ALBEDO Telecom founded in 2010 with the same

engineers that founded in 1981 ICT electronics a company sold in 2001 to Trend Communications (UK), in 2005 it was sold to Ideal Industries (US) but in 2009, after several years of negative results, decided to make redundant 95% of the personnel and closed all Departments in Barcelona. In any case, key engineers have always been nearly the same that today occupy key positions as CEO, CTO, R&D, Hardware, Software and Industrial Directors. All of them that have been innovating in the fields of synchronization, networking and testing during the last years.

Figure 9 *Flexacom, Victoria, xGenius… six generations of synchronization Nodes & Testers made by ALBEDO*

Milestones

Engineers, today working for ALBEDO, have designed and developed outstanding solutions:

- 1983: World first PCM analyzer with microprocessor
- 1989: First PDH multiplexer from 64 kbit/s up to 140 Mbit/s
- 1991: OEM to HP and Agilent
- 1996: First hand-held device incorporating a touch-screen
- 1999: World first hand-held tester for SONET/SDH
- 2009: World first portable wirespeed tap with active filters
- 2012: World first handy wirespeed WAN emulator
- 2014: World smallest 10Gb/s Ethernet, C37.94 tester
- 2015: First double port C37.94 tester
- 2017: PTP Grand Master Clock
- 2018: xGenius 8' transmission & synchronization platform

test + measurement + WAN emulation + packet capture + synchronization + consultancy

about ALBEDO

ALBEDO delivers solutions that enable Telecom and Power infrastructures of to verify, install, troubleshoot, monitor and migrate mission critical networks. From the Substation to the GNSS installation, from Access Network, Ethernet, Sync-E, PTP, Optical backbones, 5G, LTE, VoIP, T1/E1 or TR-069 applications.

On local segments and across distributed networks, ALBEDO enable Manufacturers, Power/Telecom/Finance installations, Utilities, Network Operators, ISP and Contents Providers to quickly check the health of your network, verify SLA, or find and fix problems.

Benefits

Results. ALBEDO helps the technological industry to make the most of the investment on communication and protection infrastructures.

Expertise. ALBEDO trainers, auditors, engineers and consultants provide industry-leading knowledge to address the unique needs of customers.

Integration. ALBEDO integrates disparate power and telecom resources and applications, realizing new business efficiencies.

Agility. ALBEDO increases the ability of customers to respond quickly to new market opportunities and requirements.

Coverage. ALBEDO offers solutions that facilitates the migration and the roll-out to new telecom and protection architectures.

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in Test we Trust

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aims

+ **LEARN** from business models and case studies
+ **UNDERSTAND** the potential of interoperability with legacy services
+ **EXPERIENCE** specialised synchronization network solutions
+ **ASSESS** different solutions for installation and maintenance